Introduction to AGWA2
The Automated Geospatial Watershed Assessment Tool

Land cover change and hydrologic response

Introduction	In this exercise you will investigate the manner in which land cover changes over a 5 year period have affected runoff processes in/around Denver, CO.
Goal	To familiarize yourself with AGWA2 and the various uses and limitations of hydrologic modeling for landscape assessment.
Assignment	Run the SWAT model on a HUC10 watershed in the Middle South Platte-Cherry Creek HUC8 and the KINEROS model on a HUC12 using 2001 and 2006 NLCD land cover.

A Short Introduction to Hydrologic Modeling for Watershed Assessment

The basic tenet of watershed management is that direct and powerful linkages exist among spatially distributed watershed properties and watershed processes. Stream water quality changes, especially due to erosion and sediment discharge, have been directly linked to land uses within a watershed. For example, erosion susceptibility increases when agriculture is practiced on relatively steep slopes, while severe alterations in vegetation cover can produce up to 90% more runoff than in watersheds unaltered by human practices.

The three primary watershed properties governing hydrologic variability in the form of rainfall-runoff response and erosion are soils, land cover, and topography. While topographic characteristics can be modified on a small scale (such as with the implementation of contour tillage or terracing in agricultural fields), variation in watershed-scale hydrologic response through time is primarily due to changes in the type and distribution of land cover.

Watershed modeling techniques are useful tools for investigating interactions among the various watershed components and hydrologic response (defined here as rainfall-runoff and erosion relationships). Physically-based models, such as the KINEmatic Runoff and EROSion model (KINEROS) are designed to simulate the physical processes governing runoff and erosion (and subsequent sediment yield) on a watershed. Lumped parameter models such as the Soil & Water Assessment Tool (SWAT) are useful strategic models for investigating long-term watershed response. These models can be useful for understanding and interpreting the various interactions among spatial characteristics insofar as the models are adequately representing those processes.

The percentage and location of natural land cover influences the amount of energy that is available to move water and materials. Forested watersheds dissipate energy associated with rainfall, whereas watersheds with bare ground and anthropogenic cover are less able to do so. The percentage of the watershed surface that is impermeable, due to urban and road surfaces, influences the volume of water that runs off and increases the amount of sediment that can be moved. Watersheds with highly erodible soils tend to have greater potential for soil loss and sediment delivery to streams than watersheds with non-erodible soils. Moreover, intense precipitation events may exceed the energy threshold and move large amounts of sediments across a degraded watershed (Junk et al., 1989; Sparks, 1995). It is during these events that human-induced landscape changes may manifest their greatest negative impact.

The Study Area

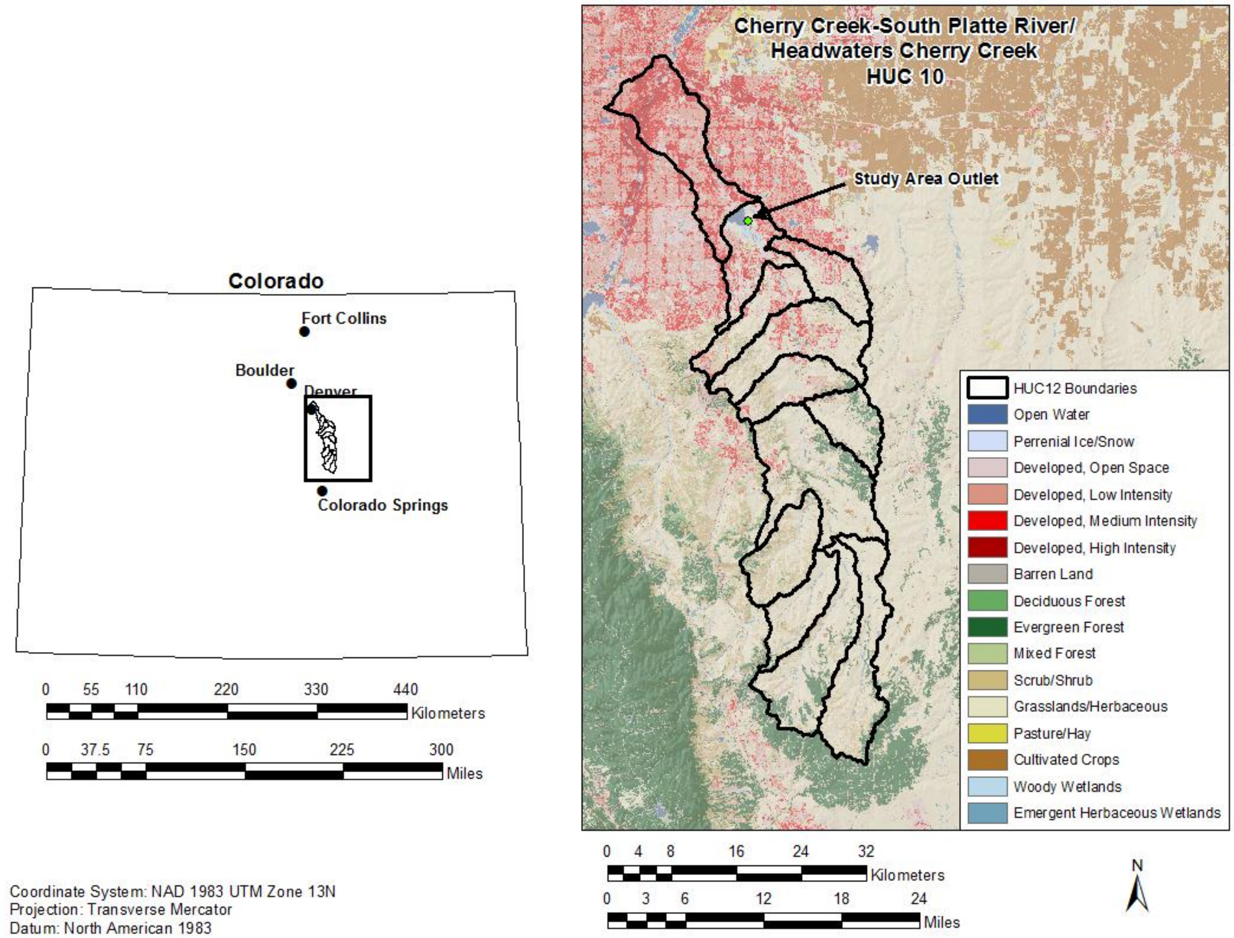


Figure 1. Location Map of the study area, near Denver, Colorado.

This exercise examines the effects of land cover change on the hydrology of a particular watershed near Denver, Colorado. The results disclose immediate changes to the hydrologic regime that are attributable to development and land cover change.

Getting Started

Start ArcMap with a new empty map. Save the empty map document as **tutorial_SouthPlatte** in the **C:\AGWA2\mxds** directory. If the AGWA2 Toolbar is not visible, turn it on by selecting the *AGWA2 Toolbar* from *Customize -> Toolbars* on the ArcMap Main Menu bar. Once the map document is opened and saved, set the HOME and TEMP directories by selecting the *AGWA2 Preferences* menu item from *AGWA2 Tools -> Other Options* on the *AGWA2 Toolbar*.

- HOME: **C:\AGWA2**
- TEMP: **C:\AGWA2\temp**

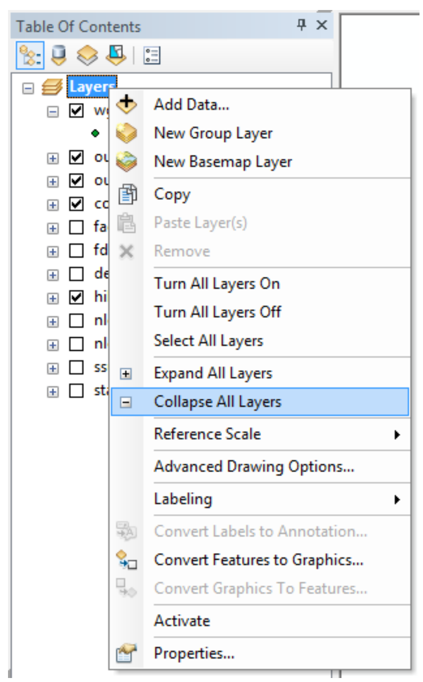
GIS Data

Add the GIS data to the map by clicking on the *Add Data* button below the menu bar at the top of the screen. Navigate to the **C:\AGWA2\gisdata\tutorials\tutorial_SouthPlatte** folder and add the following datasets and layers:

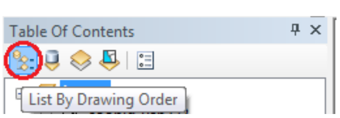
- **dem10mf**
- **facg10m**
- **fdg10m**
- **hillshade10m**
- **huc12.shp**
- **nlcd2001**
- **nlcd2006**
- **outlet_KINEROS.shp**
- **outlet_SWAT.shp**
- **raingages.shp**
- **ssurgo_PineyCreek.shp**
- **statsgo.shp**

You will also need to add the following files from the **C:\AGWA2\datafiles** folder:

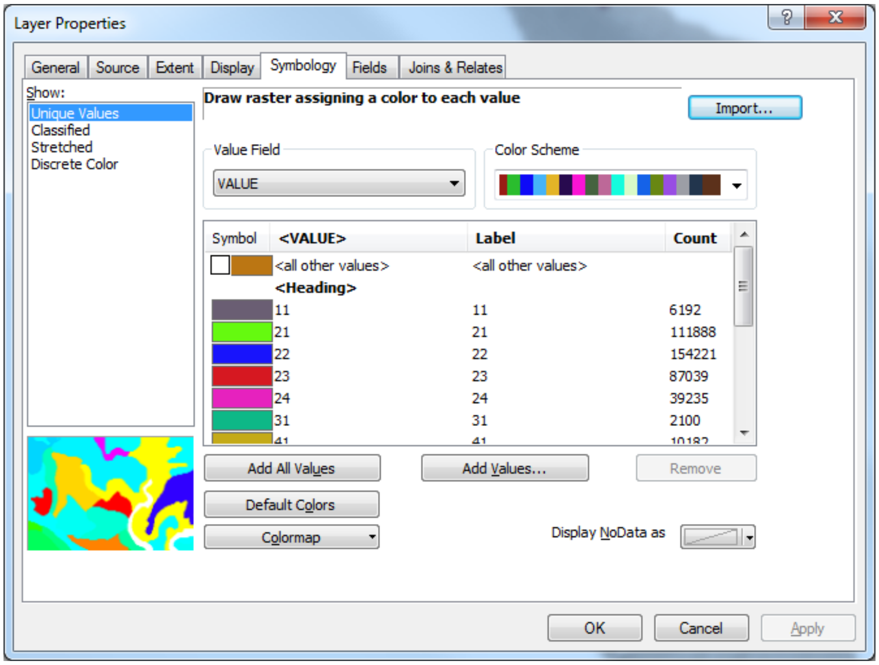
- **lc_luts\mrlc2001_lut.dbf** – MRLC look-up table for 2001 and 2006 NLCD land cover
- **precip\CO\coopid_056323.dbf** – unweighted precipitation data for gage in the study area
- **wgn\wgn_us83.shp** – weather generator stations for SWAT

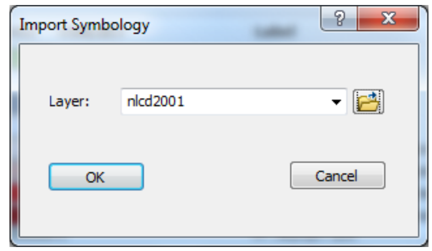


You may want to collapse the legends and rearrange the order of the layers to better see what is going on. Click on the minus box next to the layer name in the Table of Contents to collapse the legend, or right-click on the Layers dataframe and select *Collapse All Layers*. Click and drag the layers by their names in Table of Contents to rearrange layer order. If you cannot rearrange the layer order, you may need to select the *List By Drawing Order* button in the *Table Of Contents*.



To better visualize the different land cover types and associate the pixels with their classification, load a legend into the **nlcd2001** and **nlcd2006** datasets. To do this, right click the layer name of the **nlcd2001** dataset in the *Table of Contents* and select *Properties* from the context menu that appears. Select the





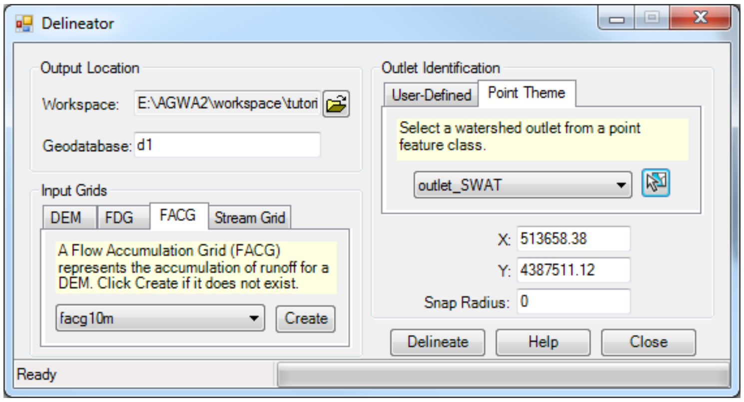
Symbology tab from the form that opens. In the *Show* box on the left side of the form, select *Unique Values* and click the *Import* button on the right. Click the file browser button, navigate to and select **C:\AGWA2\datafiles\renderers\nlcd2001.lyr**, and click OK to apply the symbology and exit the *Import Symbology* form.

The **nlcd2001** and **nlcd2006** datasets have the same legend and classification, so repeat the same procedure for the **nlcd2006** dataset.

Part 1: Modeling Runoff at the Basin Scale Using SWAT

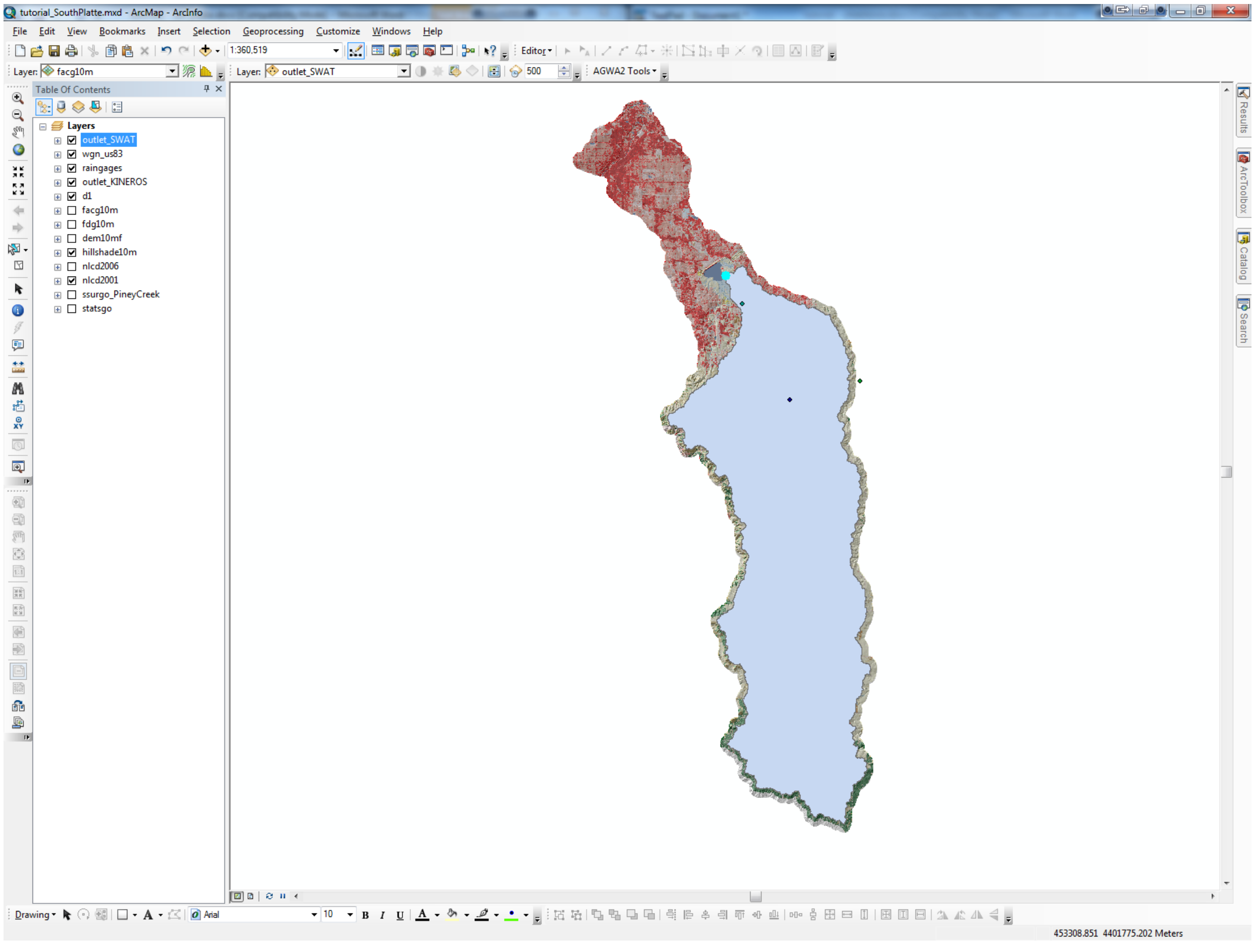
In Part 1, you will evaluate the impact of land use change from 2001 to 2006 using the National Land Cover Database (NLCD) on the Cherry Creek watershed down to the Cherry Creek Reservoir using the SWAT model. Watershed delineation, discretization, and parameterization will be covered, along with precipitation input file preparation, model execution, and results visualization.

1. Perform the watershed delineation by selecting the *Delineate Watershed* menu item from the *AGWA2 Tools -> Delineation Options* menu.

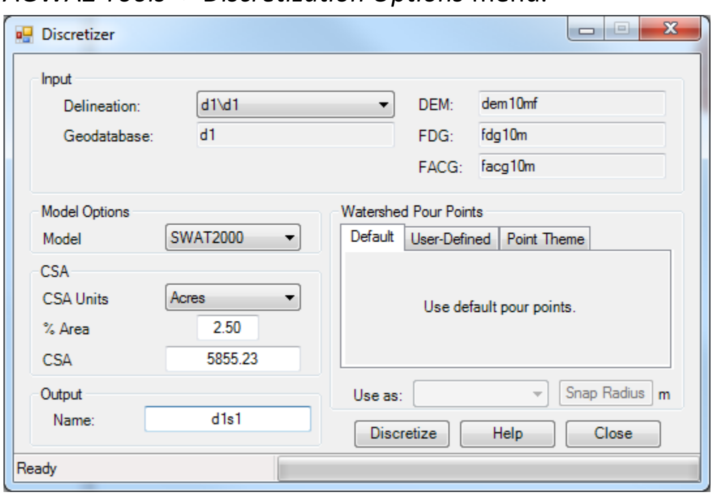


   A. *Output Location* box
      I. *Workspace* textbox: navigate to and select/create **C:\AGWA2\workspace\tutorial_SouthPlatte**
      II. *Geodatabase* textbox: **d1**
   B. *Input Grids* box
      I. *DEM* tab: select **demf10m** (do not click Fill)
      II. *FDG* tab: select **fdg10m** (do not click Create)
      III. *FACG* tab: select **facg10m** (do not click Create)
      IV. *Stream Grid* tab: do nothing
   C. *Outlet Identification* box
      I. *Point Theme* tab
         a. *Outlets theme*: select **outlet_SWAT**
         b. Click the *Select Feature* button  and draw a rectangle around the point.
   D. Click *Delineate*.
   E. Save the map document and continue to the next step.

At this point, the Cherry Creek watershed is delineated. The workspace specified is the location on your hard drive where the delineated watershed is stored as a feature class in a geodatabase. The discretization created next will also be stored in the geodatabase.



2. Perform the watershed discretization by selecting the *Discretize Watershed* menu item from the *AGWA2 Tools -> Discretization Options* menu.



A. *Input* box
   I. *Delineation*: select **d1\d1**

B. *Model Options* box
   I. *Model*: select **SWAT2000**

C. *CSA* box

   I. *CSA Units*: do nothing (the default is acres)

   II. *% Area*: do nothing (the default is 2.5% of the total watershed area)

   III. CSA: do nothing (the default 2.5% Area equates to 5855.23 acres)

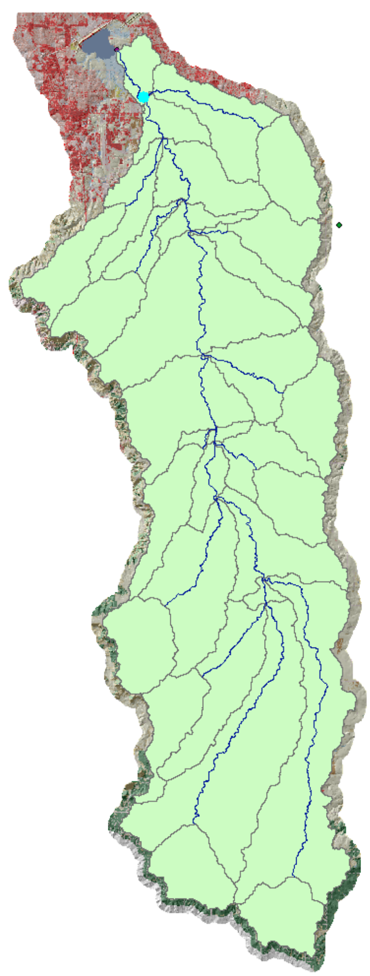
D. *Output* box

   I. *Name*: enter **d1s1**

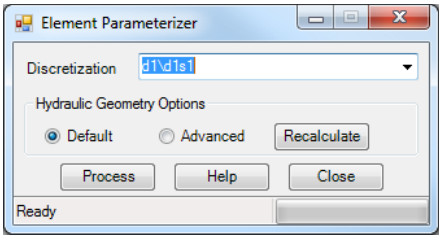
E. Click *Discretize*.

F. Save the map document and continue to the next step.

Discretizing breaks up the delineation/watershed into model specific elements and creates a stream feature class that drains the elements. The CSA, or Contributing/Channel Source Area, is a threshold value which defines first order channel initiation, or the upland area required for channelized flow to begin. Smaller CSA values results in a more complex watershed. The default CSA in AGWA is set to 2.5% of the total watershed area. The discretization process created a subwatersheds layer with the name **subwatersheds_d1s1** name and a streams map named **streams_d1s1**. In AGWA2 discretizations, are referred to with their geodatabase name as a prefix followed by the discretization name given in the *Discretizer* form, e.g. **d1\d1s1**.



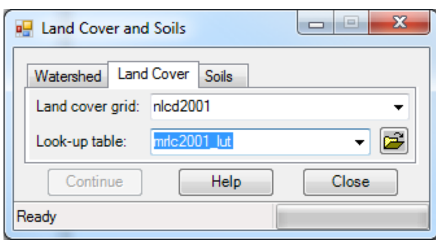
3. Perform the element parameterization of the watershed by selecting the *Element Parameterizer* menu item from the *AGWA2 Tools -> Parameterization Options* menu.

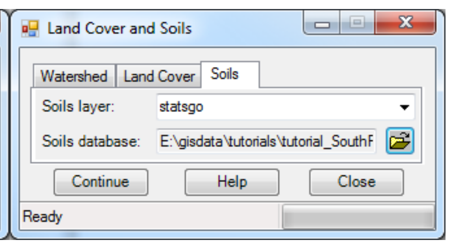


   A. *Discretization* combobox: select **d1\d1s1**
   B. *Hydraulic Geometry Options* box: select the ***Default*** radiobutton
   C. Click *Process*.

Element parameterization defines topographic properties of the subwatershed and channel elements. The properties defined depend on the model, but examples of SWAT properties include mean elevation, max flow length, and average slope for subwatershed elements and routing sequence, average slope, and channel dimensions for channel elements.

4. Perform the land cover and soils parameterization of the watershed by selecting the *Land Cover and Soils Parameterization* menu item from the *AGWA2 Tools -> Parameterization Options* menu.

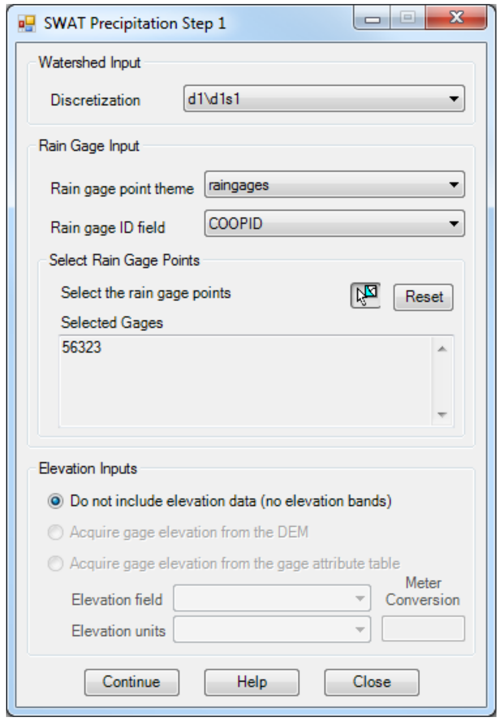




   A. *Watershed* tab
      I. *Discretization*: select **d1\d1s1**
   B. *Land Cover* tab
      I. *Land cover grid*: select **nlcd2001**
      II. Look-up table: select **mrlc2001_lut**
   C. *Soils* tab
      I. *Soils layer*: select **statsgo**
      II. *Soils database*: navigate to and select **C:\AGWA2\gisdata\tutorials\tutorial_SouthPlatte\soildb_US_2002_statsgo_CO.mdb**
   D. Click *Continue*.

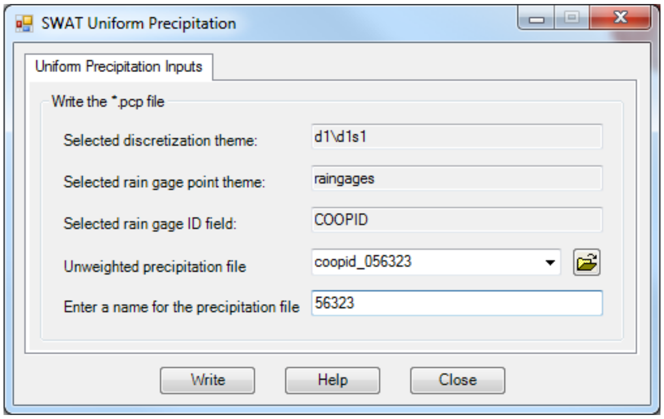
Land cover and soils parameterization defines land cover and soils properties of the subwatershed elements. The properties defined depend on the model, but examples of SWAT properties include the dominant soil type/id, curve number, and percent cover for subwatershed elements.

5. Write the SWAT precipitation file for the watershed by selecting the *Write SWAT Precipitation* menu item from the *AGWA2 Tools -> Precipitation Options* menu.



A. *SWAT Precipitation Step 1* form
   I. *Watershed Input* box:
      a. Discretization: **d1\d1s1**
   II. *Rain Gage Input* box:
      a. *Rain gage point theme*: **raingages**
      b. *Rain gage ID field*: **COOPID**
   III. *Select Rain Gage Points* box
      a. Click the *Select Feature* button to select the Parker raingage in the view (the figure, above left, displays the location of the gage). The id number, 56323, of the selected gage will be displayed in the Selected Gages textbox.
   IV. *Elevation Inputs* box: *Do not include elevation data (no elevation bands)*
   V. Click *Continue*.

B. *SWAT Uniform Precipitation* form



I. *Write the *.pcp file* box:

a. *Selected discretization theme* (disabled): **d1\d1s1**

b. *Selected rain gage point theme* (disabled): **raingages**

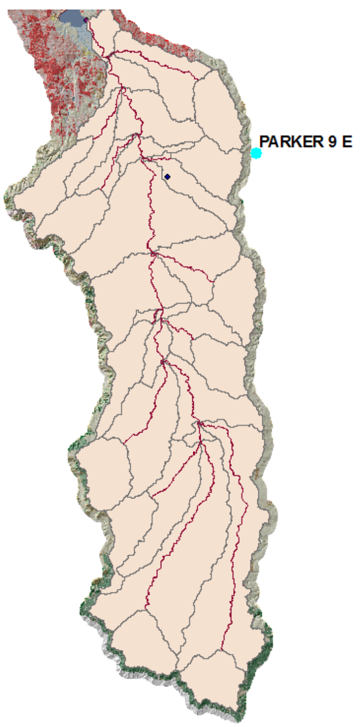
c. *Selected rain gage ID field* (disabled): **COOPID**

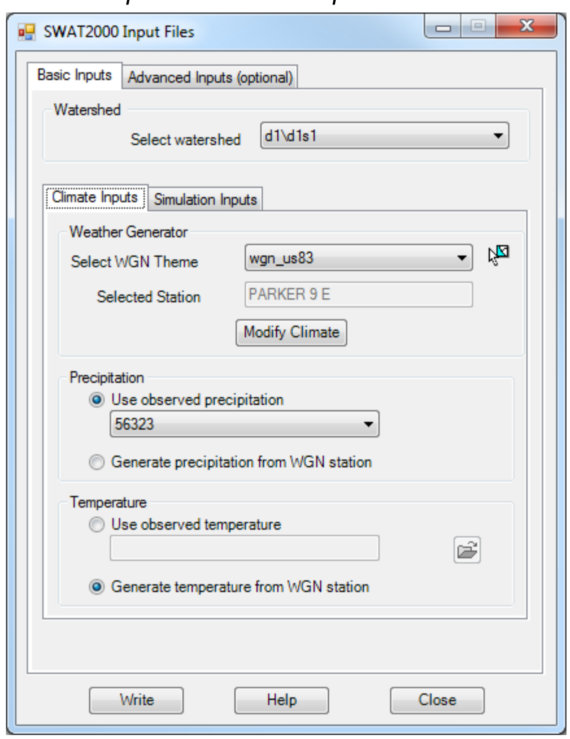
d. *Unweighted precipitation file*: **coopid_056323**

e. *Enter a name for the precipitation file*: **56323**

f. Click *Write*.

6. Write the SWAT simulation input files for the watershed by selecting the *Write SWAT Input Files* menu item from the *AGWA2 Tools -> Simulation Options -> SWAT Options* menu.





A. *Basic Inputs* tab:

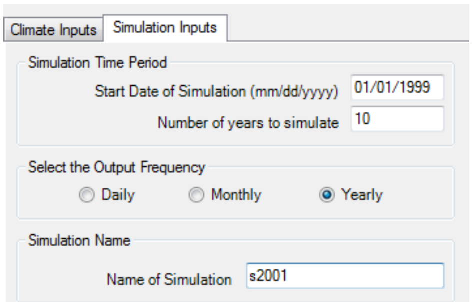
I. *Watershed* box: **d1\d1s1**

II. *Climate Inputs* tab:

a. *Weather Generator* box:

        a. *Select WGN Theme*: **wgn_us83**
        b. *Selected Station*: **PARKER 9 E** (see above left for location)
    b. Precipitation box:
        a. *Use observed precipitation*: **56323**
    c. *Temperature* box:
        a. ***Generate temperature from WGN station***

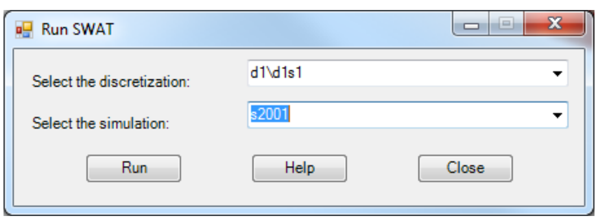
III. *Simulation Inputs* tab:



    a. *Simulation Time Period* box:
        a. *Start Date of Simulation (mm/dd/yyyy)*: **01/01/1999**
        b. *Number of years to simulate*: **10**
    b. *Select the Output Frequency* box: **Yearly**
    c. *Simulation Name* box: **s2001**

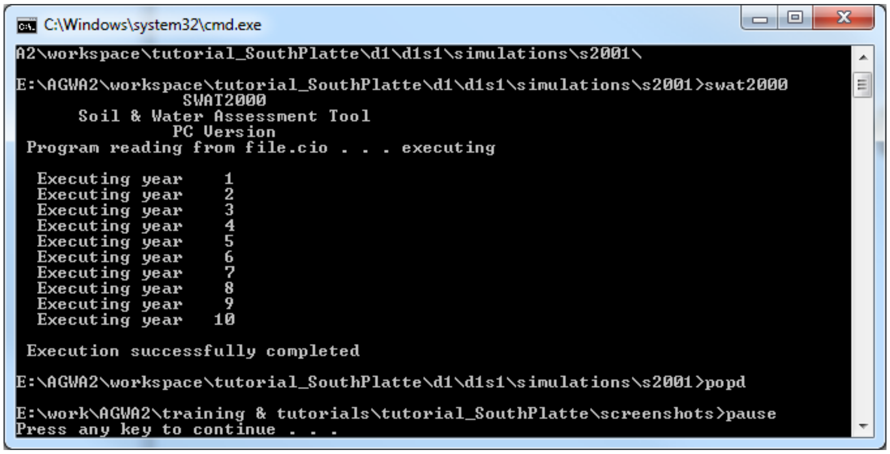
IV. Click *Write*.

7. Run the SWAT model for the Cherry Creek watershed by selecting the *Execute SWAT Model* menu item from the *AGWA2 Tools -> Simulation Options -> SWAT Options* menu.



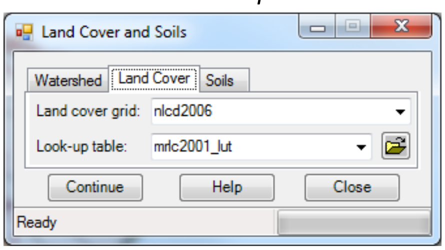
    A. *Select the discretization*: select **d1\d1s1**
    B. *Select the simulation*: select **s2001**
    C. Click *Run*. The command window will stay open so that successful completion can be verified. Press any key to continue.

D. Close the *Run SWAT* form.



At this point, the 2001 land cover has been simulated; 2006 land cover will be parameterized and simulated next. Model input/output files were written into a subdirectory of the workspace following the name of the geodatabase and discretization.

8. Rerun the land cover and soils parameterization of the watershed, with the 2006 land cover this time, by selecting the *Land Cover and Soils Parameterization* menu item from the *AGWA2 Tools -> Parameterization Options* menu.

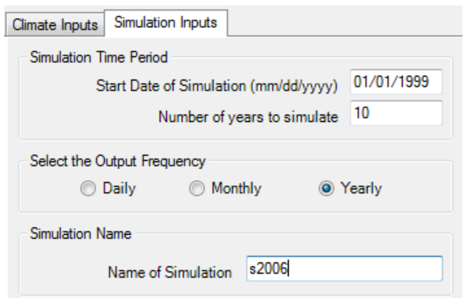


   A. *Watershed* tab
      I. *Discretization*: select **d1\d1s1**
   B. *Land Cover* tab
      I. *Land cover grid*: select **nlcd2006**
      II. Look-up table: select **mrlc2001_lut**
   C. *Soils* tab
      I. *Soils layer*: select **statsgo**
      II. *Soils database*: navigate to and select **C:\AGWA2\gisdata\tutorials\tutorial_SouthPlatte\soildb_US_2002_statsgo_CO.mdb**

The **nlcd2001** and **nlcd2006** datasets have the same classification, so the same look-up table is used for both datasets.

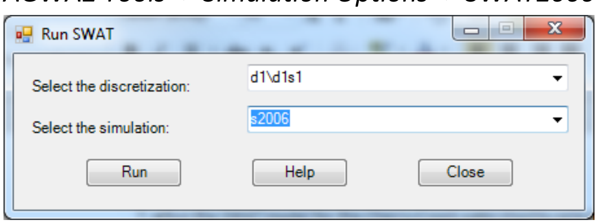
9. Write the SWAT simulation input files representing the new parameterization by selecting the *Write Input Files* menu item from the *AGWA2 Tools -> Simulation Options -> SWAT2000* menu.
   A. *Basic Inputs* tab:

I. *Watershed* box: **d1\d1s1**
II. *Climate Inputs* tab:
    a. *Weather Generator* box:
        a. *Select WGN Theme*: **wgn_us83**
        b. *Selected Station*: **PARKER 9 E**
    b. Precipitation box:
        a. *Use observed precipitation*: **56323**
    c. *Temperature* box:
        a. ***Generate temperature from WGN station***
    d. *Simulation Inputs* tab:



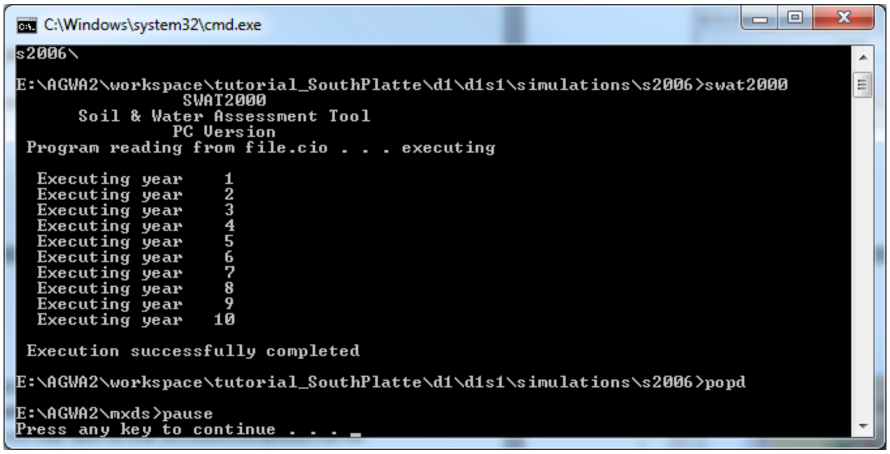
        a. *Simulation Time Period* box:
        b. *Start Date of Simulation (mm/dd/yyyy)*: **01/01/1999**
        c. *Number of years to simulate*: **10**
    e. *Select the Output Frequency* box: **Yearly**
    f. *Simulation Name* box: **s2006**
III. Click *Write*.

10. Run the SWAT model for the 2006 land cover by selecting the *Run SWAT* menu item from the *AGWA2 Tools -> Simulation Options -> SWAT2000* menu.



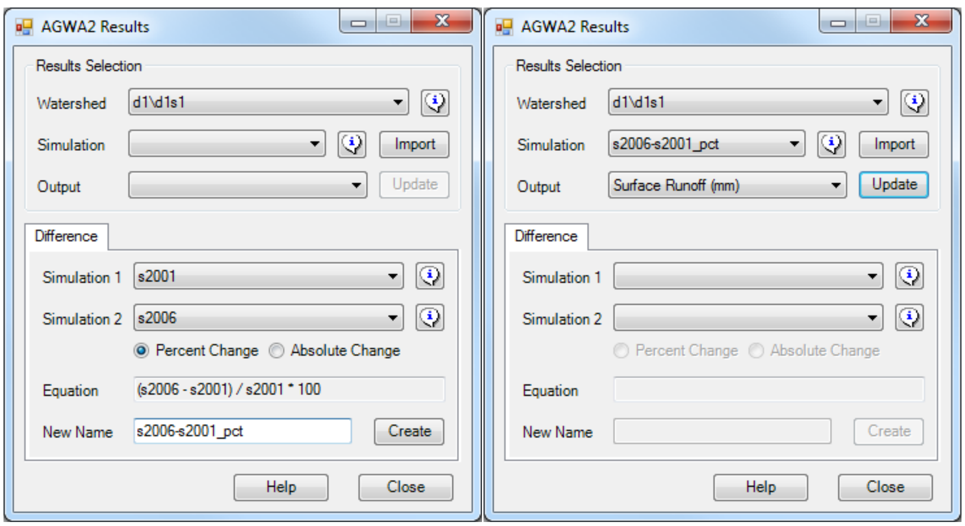
    A. *Select the discretization*: select **d1\d1s1**
    B. *Select the simulation*: select **s2006**
    C. Click *Run*. The command window will stay open so that successful completion can be verified. Press any key to continue.

D. Close the *Run SWAT* form.



The model was run for both 2001 and 2006 land covers and now the model results will be imported into AGWA. These results will then be differenced to visually see how the land cover changes impact the hydrology of the watershed.

11. Import the results from the two simulations by selecting the *View SWAT Results* menu item from the *AGWA2 Tools -> View Results* menu.



A. Results Selection box
   I. *Watershed*: select **d1\d1s1**
   II. *Simulation*: click **Import**
      a. **Yes** to importing **s2001**
      b. **Yes** to importing **s2006**

12. Difference the 2001 and 2006 simulation results.

A. *Difference* tab
   I. *Simulation1*: select **s2001**
   II. *Simulation2*: select **s2006**
   III. Select **Percent Change** radiobutton
   IV. *New Name*: enter **s2006-s2001_pct**

V. Click **Create**

13. View the differenced results.

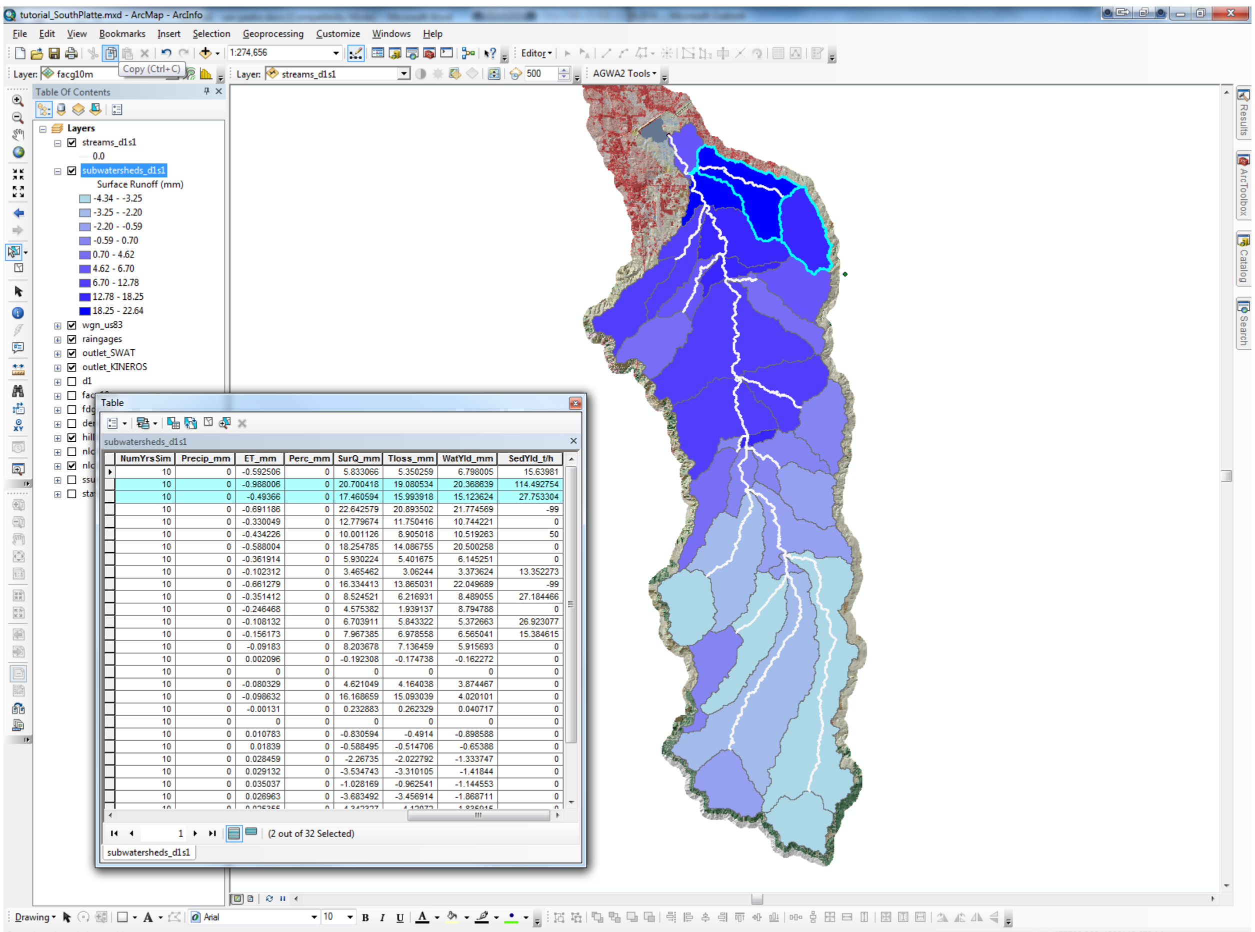
    A. *Results Selection* box

        I. *Watershed*: select **d1\d1s1**

        II. *Simulation*: select **s2006-s2001_pct**

        III. *Output*: select **Surface Runoff (mm)**

        IV. Click **Update**.

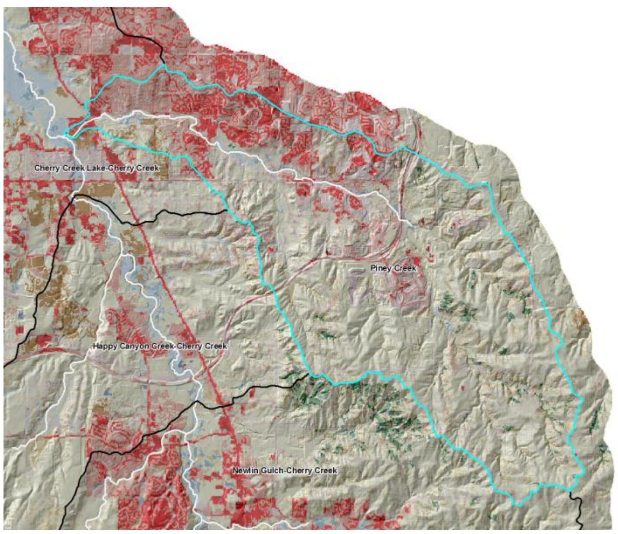


Some of the subwatersheds experienced up to a 22% increase in surface runoff caused by changes in land cover between 2001 and 2006. In part 2 of this tutorial, we will zoom in to one of the subwatersheds that experienced a high increase in surface runoff and model it in more detail using the KINEROS model.

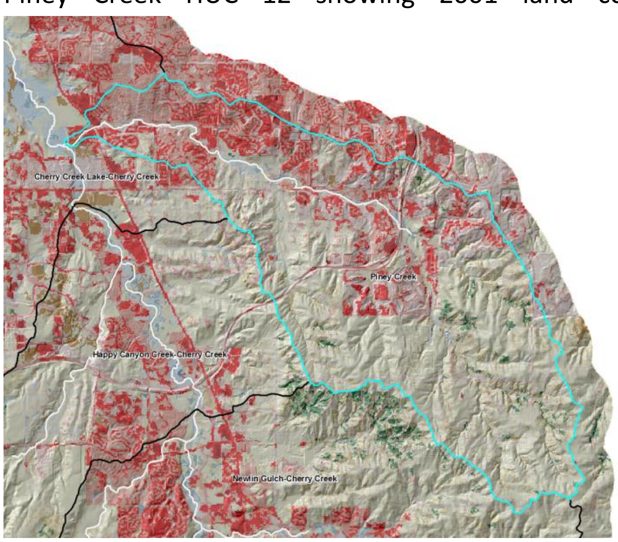
Part 2: Modeling Runoff at the Small Watershed Scale Using KINEROS

In Part 1, you identified a region that underwent significant change in terms of landscape characteristics and hydrology. Small scale/large extent assessments are useful for detecting large patterns of change; you will use the results from Part 1 to zoom in on a subwatershed to investigate the changes at a larger scale/smaller extent and how they may affect runoff from simulated rainfall events. A quick review of the spatial distribution of changes in surface runoff predicted by SWAT in Part 1 shows that one of the larger increases occurred in the Piney Creek HUC12, which showed an increase in developed land cover types between 2001 and 2006.

SWAT is a continuous simulation model, and in Part 1 you simulated runoff for 10 years on a yearly basis. KINEROS is an event-based model, and in Part 2 you will use design storms to simulate the runoff and sediment yield resulting from a single storm. In this case, you will use the 25-year, 6-hour return period event taken from NOAA Atlas 2 Volume 3.

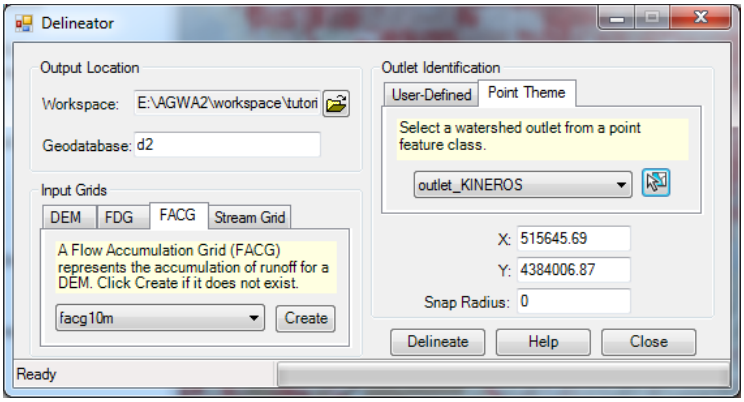


Piney Creek HUC 12 showing 2001 land cover.

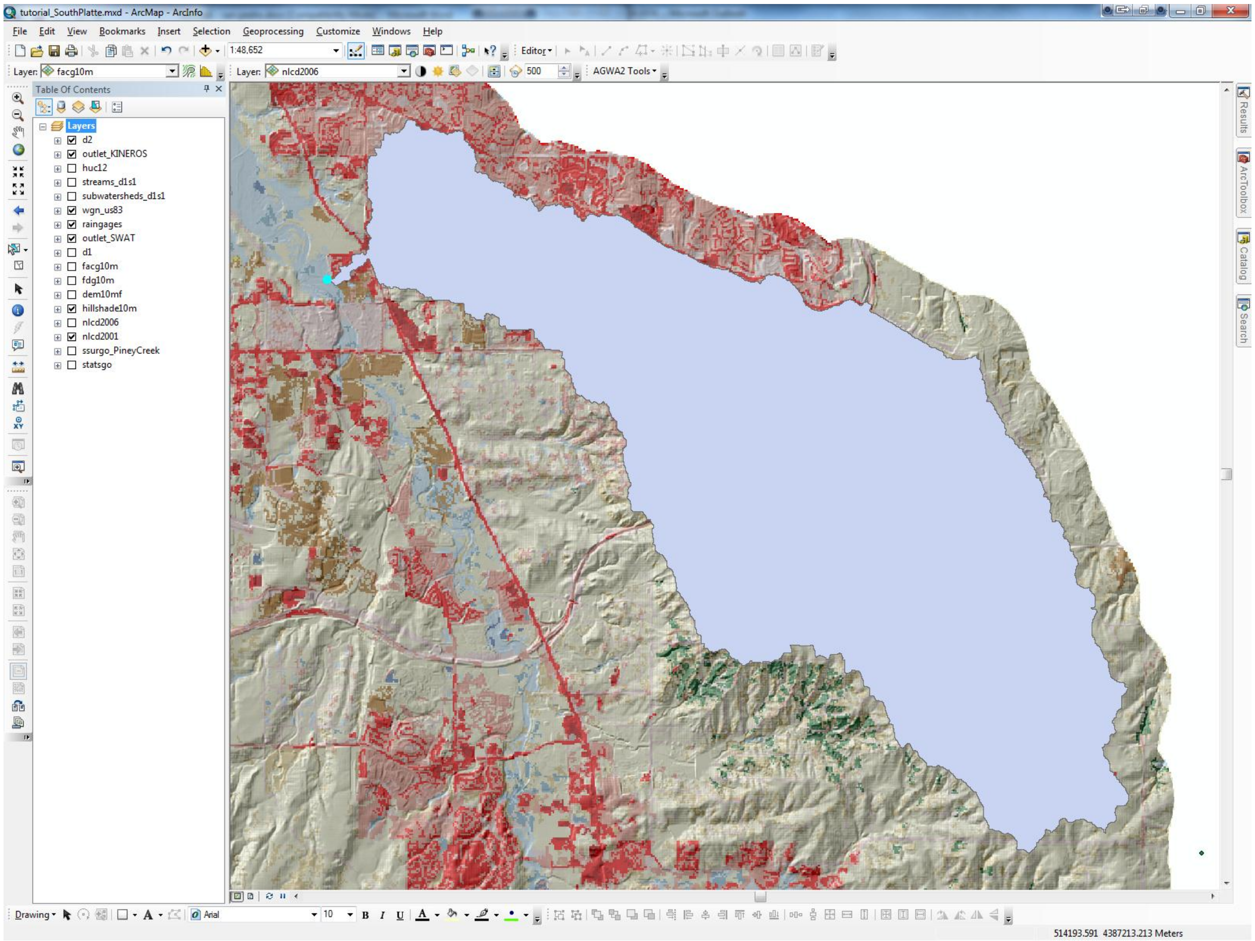


Piney Creek HUC 12 showing 2006 land cover.

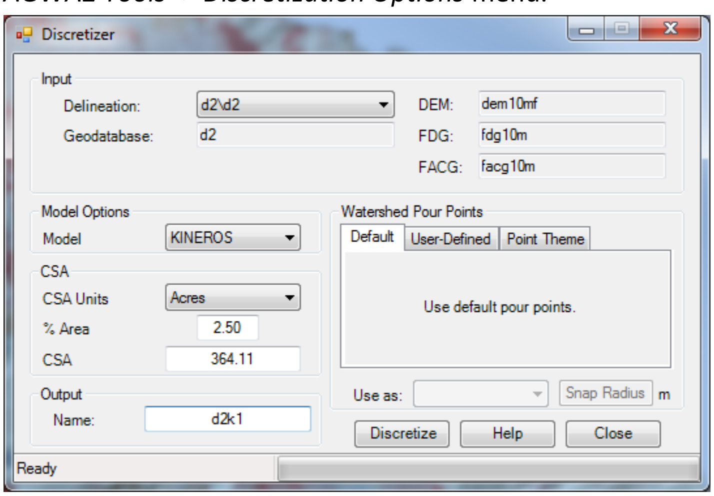
1. Perform the watershed delineation by selecting the *Delineate Watershed* menu item from the *AGWA2 Tools -> Delineation Options* menu.



   A. *Output Location* box
      I. *Workspace* textbox: navigate to and select/create **C:\AGWA2\workspace\tutorial_SouthPlatte**
      II. *Geodatabase* textbox: **d2**
   B. *Input Grids* box
      I. *DEM* tab: select **demf10m** (do not click Fill)
      II. *FDG* tab: select **fdg10m** (do not click Create)
      III. *FACG* tab: select **facg10m** (do not click Create)
      IV. *Stream Grid* tab: do nothing
   C. *Outlet Identification* box
      I. *Point Theme* tab
         a. *Outlets theme*: select **outlet_KINEROS**
         b. Click the *Select Feature* button and draw a rectangle around the point.
   D. Click *Delineate*.
   E. Save the map document and continue to the next step.



2. Perform the watershed discretization by selecting the *Discretize Watershed* menu item from the *AGWA2 Tools -> Discretization Options* menu.



A. *Input* box

I. *Delineation*: select **d2\d2**

II. *Model Options* box

B. *Model*: select **KINEROS**

C. *CSA* box

  I. *CSA Units*: do nothing (the default is acres)

  II. *% Area*: do nothing (the default is 2.5% of the total watershed area)

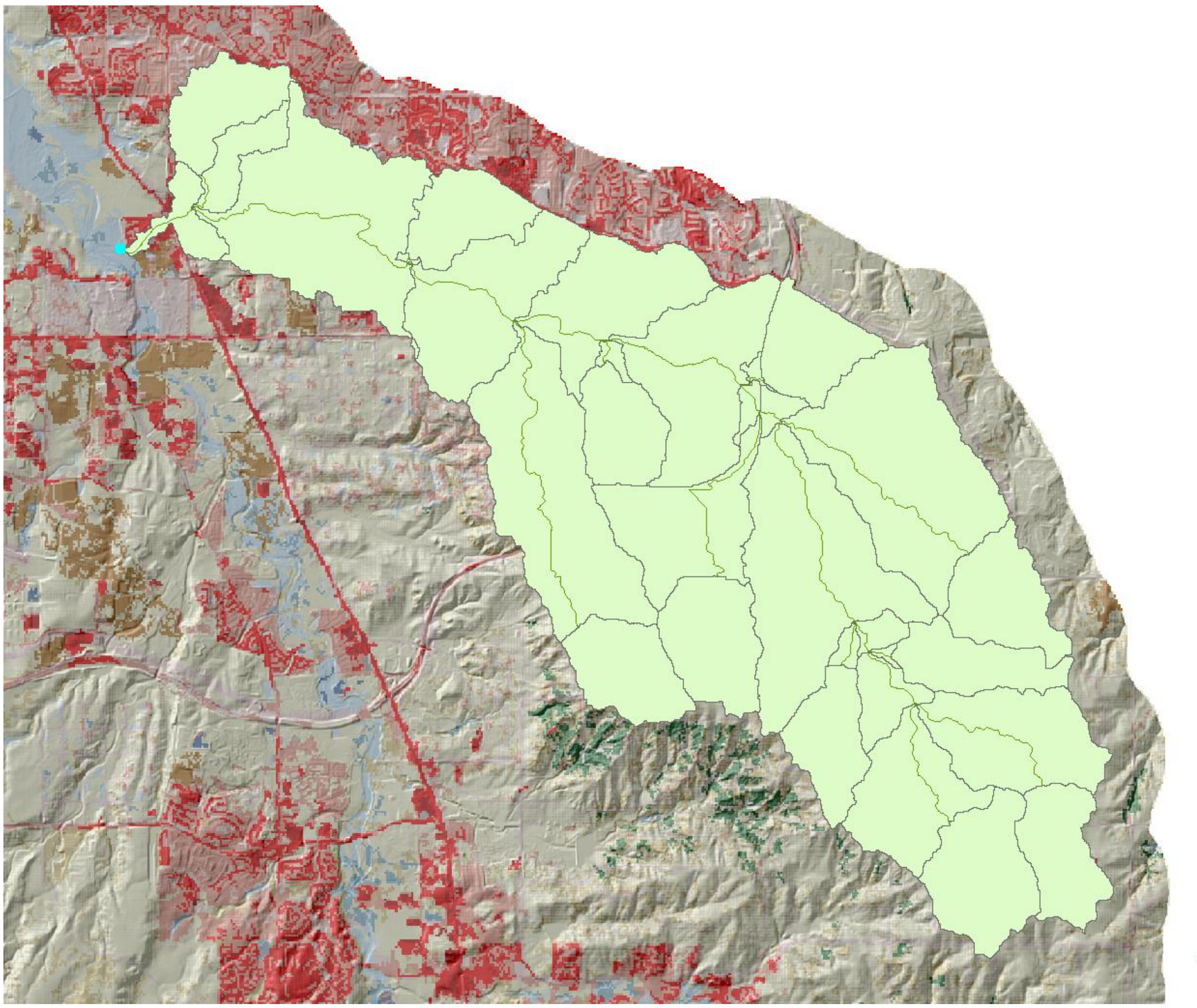
  III. CSA: do nothing (the default 2.5% Area equates to 364.11 acres)

D. *Output* box

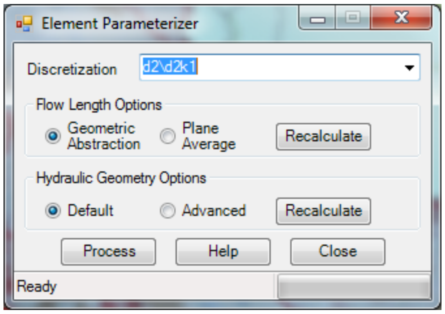
  I. *Name*: enter **d2k1**

E. Click *Discretize*.

F. Save the map document and continue to the next step.

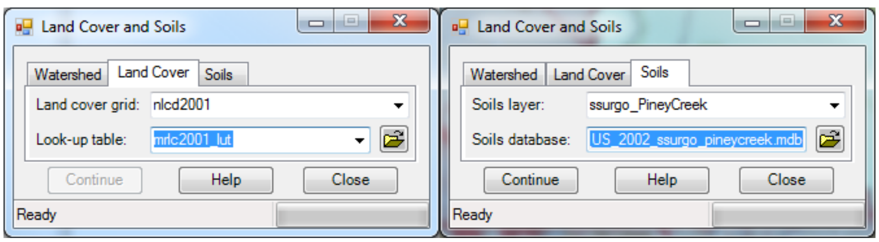


3. Perform the element parameterization of the watershed by selecting the *Element Parameterizer* menu item from the *AGWA2 Tools -> Parameterization Options* menu.



   A. *Discretization* combobox: select **d2\d2k1**
   B. *Flow Length Options*: select **Geometric Abstraction**
   C. *Hydraulic Geometry Options* box: select the ***Default*** radiobutton
   D. Click *Process*.

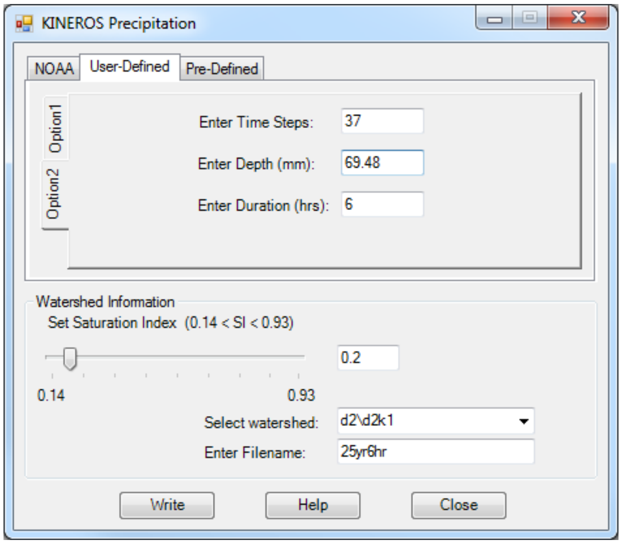
4. Perform the land cover and soils parameterization of the watershed by selecting the *Land Cover and Soils Parameterization* menu item from the *AGWA2 Tools -> Parameterization Options* menu.



   A. *Watershed* tab
      I. *Discretization*: select **d2\d2k1**
   B. *Land Cover* tab
      I. *Land cover grid*: select **nlcd2001**
      II. Look-up table: select **mrlc2001_lut**
   C. *Soils* tab
      I. *Soils layer*: select **ssurgo_PineyCreek**
      II. *Soils database*: navigate to and select **C:\AGWA2\gisdata\tutorials\tutorial_SouthPlatte\soildb_US_2002_ssurgo_pineycreek.mdb**
   D. Click *Continue*.

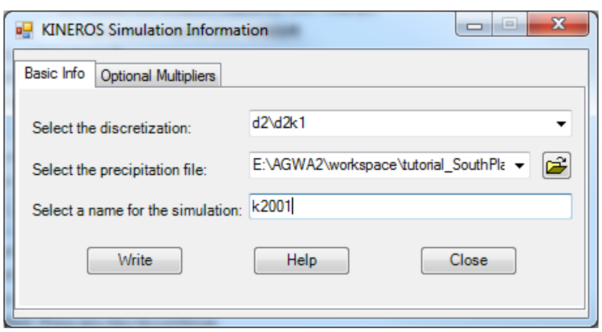
In Part 1, the smaller scale did not require high resolution soils data so the U.S. General Soil Map (STATSGO) was used at a mapping scale of 1:250000. In Part 2, because you are zooming in to a large scale, higher resolution soils data is more appropriate so SSURGO soils are used at a mapping scale of 1:24000. Note that the higher resolution data does increase processing time though; STATSGO soils has 4 soil types that intersect Piney Creek whereas SSURGO soils has 244.

5. Write the KINEROS precipitation file for the watershed by selecting the *Write KINEROS Precipitation* menu item from the *AGWA2 Tools -> Precipitation Options* menu.



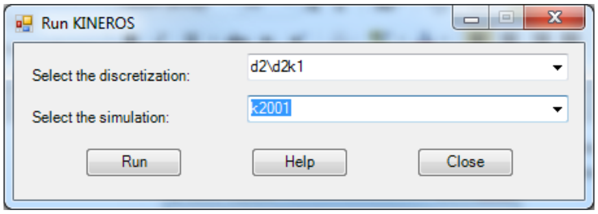
   A. *KINEROS Precipitation* form
      I. *User-Defined* tab:
         a. *Option 2* tab:
            a. *Enter Time Steps*: **37**
            b. *Enter Depth (mm)*: **69.48**
            c. *Enter Duration (hrs)*: **6**
      II. *Watershed Information* box:
         a. *Set Saturation Index* slider: **0.2**
         b. *Select Watershed*: **d2/d2k1**
         c. *Enter Filename:* **25yr6hr**
      III. Click *Write*

6. Write the KINEROS simulation input files for the watershed by selecting the *Write KINEROS Input Files* menu item from the *AGWA2 Tools -> Simulation Options -> KINEROS Options* menu.

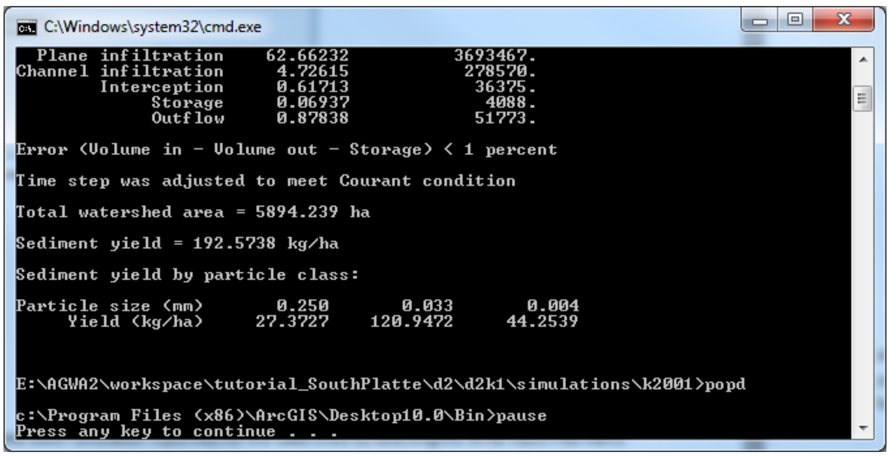


   A. *Basic Info* tab:
      I. *Select the discretization*: **d2\d2k1**
      II. *Select the precipitation file*:**25yr6hr**
      III. Select a name for the simulation: **k2001**
      IV. Click *Write*.

7. Run the KINEROS model for the Piney Creek watershed by selecting the *Execute KINEROS Model* menu item from the *AGWA2 Tools* -> *Simulation Options* -> *KINEROS* menu.

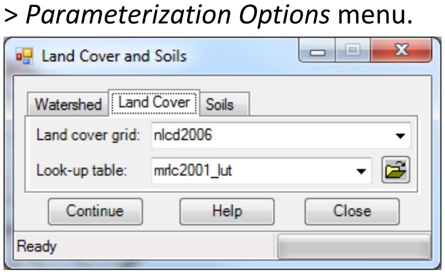


   A. *Select the discretization*: select **d2\d2k1**
   B. *Select the simulation*: select **k2001**
   C. Click *Run*. The command window will stay open so that successful completion can be verified. Press any key to continue.
   D. Close the *Run KINEROS* form.



At this point, the 2001 land cover has been simulated; 2006 land cover will be parameterized and simulated as in Part 1.

8. Rerun the land cover and soils parameterization of the watershed, with the 2006 land cover this time, by selecting the *Land Cover and Soils Parameterization* menu item from the *AGWA2 Tools* -> *Parameterization Options* menu.

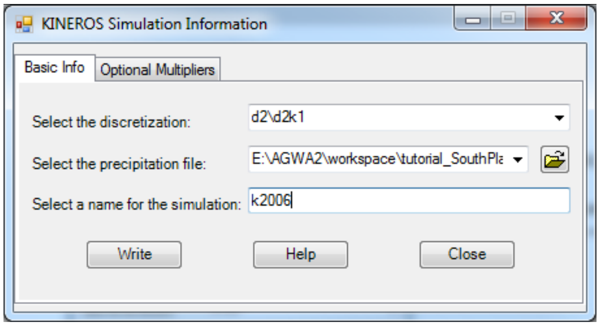


   A. *Watershed* tab
      I. *Discretization*: select **d2\d2k1**
   B. *Land Cover* tab
      I. *Land cover grid*: select **nlcd2006**
      II. Look-up table: select **mrlc2001_lut**
   C. *Soils* tab

I. *Soils layer*: select **ssurgo_PineyCreek**

II. *Soils database*: navigate to and select **C:\AGWA2\gisdata\tutorials\tutorial_SouthPlatte\soildb_US_2002_ssurgo_pineycreek.mdb**

9. Write the KINEROS simulation input files representing the new parameterization by selecting the *Write Input Files* menu item from the *AGWA2 Tools -> Simulation Options -> KINEROS* menu.



A. *Basic Info* tab:

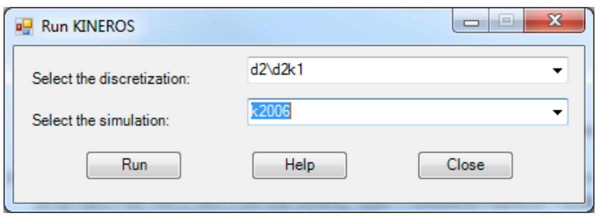
I. *Select the discretization*: **d2\d2k1**

II. *Select the precipitation file*:**25yr6hr**

III. Select a name for the simulation: **k2006**

IV. Click *Write*.

10. Run the KINEROS model for the 2006 land cover by selecting the *Run KINEROS* menu item from the *AGWA2 Tools -> Simulation Options -> KINEROS* menu.

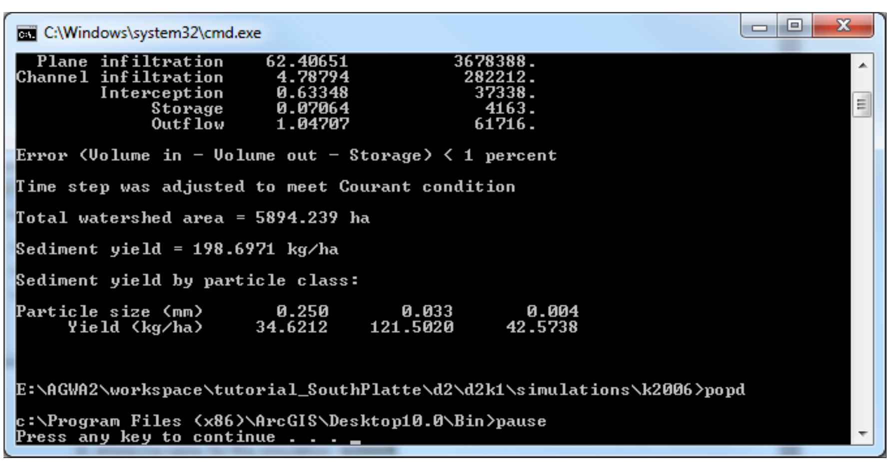


A. *Select the discretization*: select **d2\d2k1**

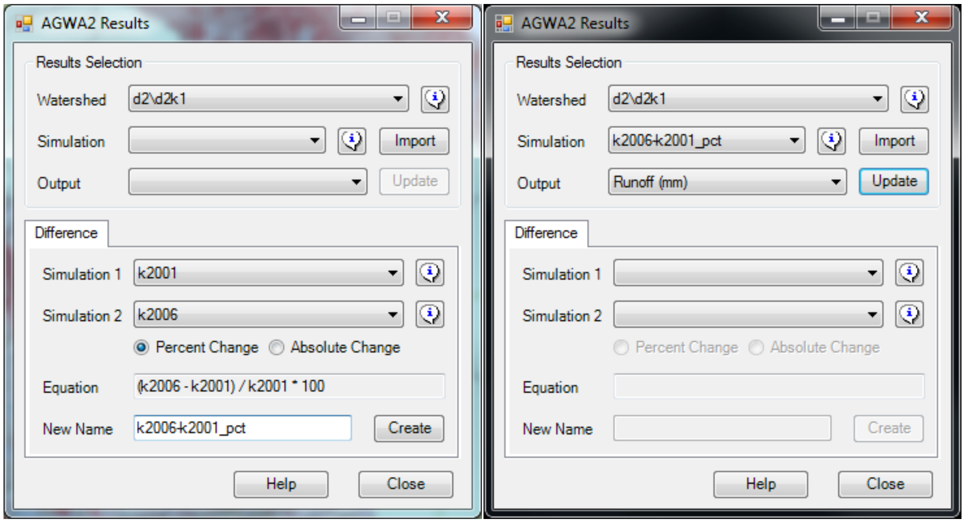
B. *Select the simulation*: select **k2006**

C. Click *Run*. The command window will stay open so that successful completion can be verified. Press any key to continue.

D. Close the *Run KINEROS* form.



11. Import the results from the two simulations by selecting the *View KINEROS Results* menu item from the *AGWA2 Tools -> KINEROS Results -> View KINEROS Results* menu.



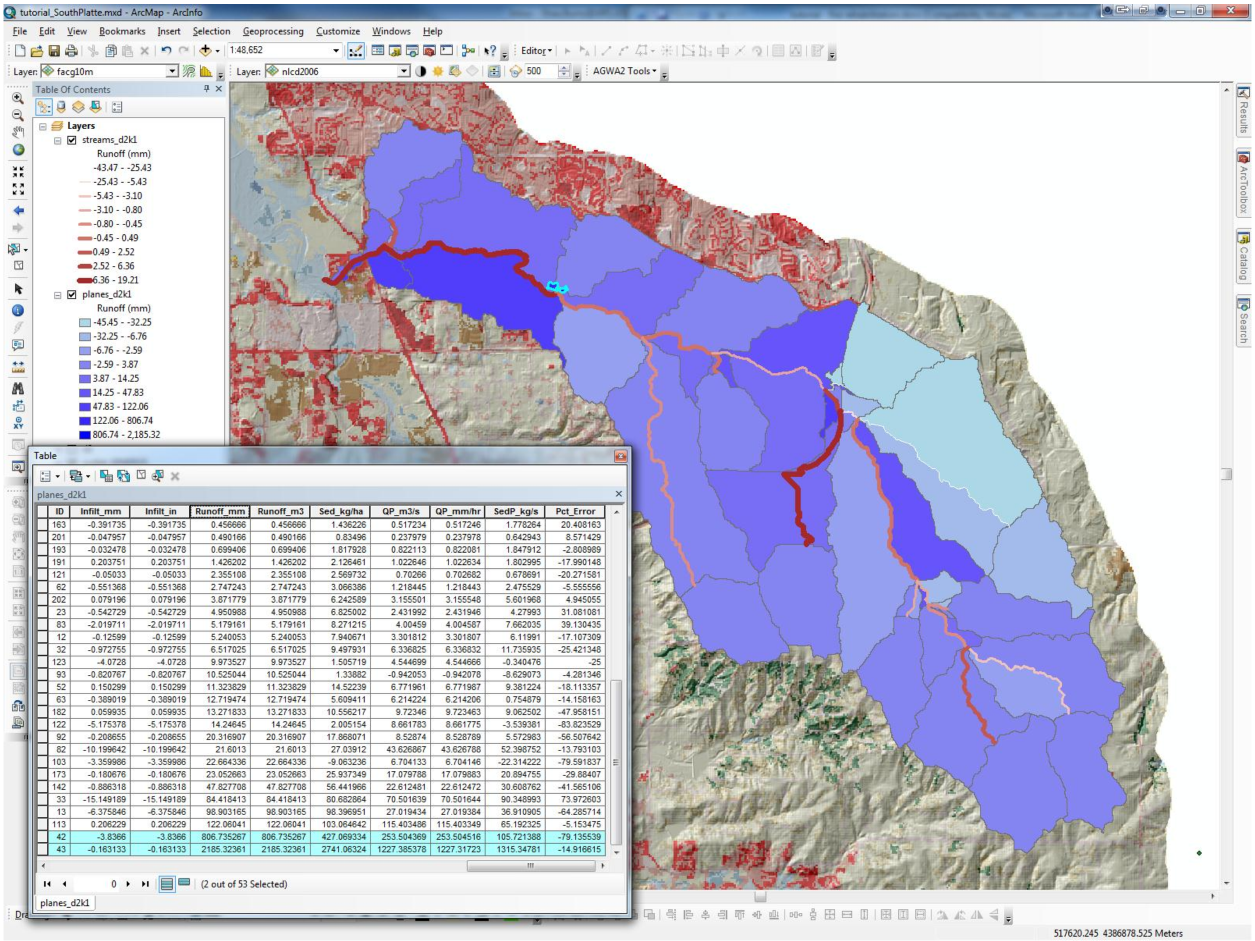
A. Results Selection box
   I. *Watershed*: select **d2\d2k1**
   II. *Simulation*: click **Import**
      a. **Yes** to importing **k2001**
      b. **Yes** to importing **k2006**

12. Difference the 2001 and 2006 simulation results.

A. *Difference* tab
   I. *Simulation1*: select **k2001**
   II. *Simulation2*: select **k2006**
   III. Select **Percent Change** radiobutton
   IV. *New Name*: enter **k2006-k2001_pct**
   V. Click **Create**

13. View the differenced results.

A. *Results Selection* box
   I. *Watershed*: select **d2\d2k1**
   II. *Simulation*: select **k2006-k2001_pct**
   III. *Output*: select **Runoff (mm)**
   IV. Click **Update**.



ID	Infilt_mm	Infilt_in	Runoff_mm	Runoff_m3	Sed_kg/ha	QP_m3/s	QP_mm/hr	SedP_kg/s	Pct_Error
163	-0.391735	-0.391735	0.456666	0.456666	1.436226	0.517234	0.517246	1.778264	20.408163
201	-0.047957	-0.047957	0.490166	0.490166	0.83496	0.237979	0.237978	0.642943	8.571429
193	-0.032478	-0.032478	0.699406	0.699406	1.817928	0.822113	0.822081	1.847912	-2.808989
191	0.203751	0.203751	1.426202	1.426202	2.126461	1.022646	1.022634	1.802995	-17.990148
121	-0.05033	-0.05033	2.355108	2.355108	2.569732	0.70266	0.702682	0.678691	-20.271581
62	-0.551368	-0.551368	2.747243	2.747243	3.066386	1.218445	1.218443	2.475529	-5.555556
202	0.079196	0.079196	3.871779	3.871779	6.242589	3.155501	3.155548	5.601968	4.945055
23	-0.542729	-0.542729	4.950988	4.950988	6.825002	2.431992	2.431946	4.27993	31.081081
83	-2.019711	-2.019711	5.179161	5.179161	8.271215	4.00459	4.004587	7.662035	39.130435
12	-0.12599	-0.12599	5.240053	5.240053	7.940671	3.301812	3.301807	6.11991	-17.107309
32	-0.972755	-0.972755	6.517025	6.517025	9.497931	6.336825	6.336832	11.735935	-25.421348
123	-4.0728	-4.0728	9.973527	9.973527	1.505719	4.544699	4.544666	-0.340476	-25
93	-0.820767	-0.820767	10.525044	10.525044	1.33882	-0.942053	-0.942078	-8.629073	-4.281346
52	0.150299	0.150299	11.323829	11.323829	14.52239	6.771961	6.771987	9.381224	-18.113357
63	-0.389019	-0.389019	12.719474	12.719474	5.609411	6.214224	6.214206	0.754879	-14.158163
182	0.059935	0.059935	13.271833	13.271833	10.556217	9.72346	9.723463	9.062502	-47.958151
122	-5.175378	-5.175378	14.24645	14.24645	2.005154	8.661783	8.661775	-3.539381	-83.823529
92	-0.208655	-0.208655	20.316907	20.316907	17.868071	8.52874	8.528789	5.572983	-56.507642
82	-10.199642	-10.199642	21.6013	21.6013	27.03912	43.626867	43.626788	52.398752	-13.793103
103	-3.359986	-3.359986	22.664336	22.664336	-9.063236	6.704133	6.704146	-22.314222	-79.591837
173	-0.180676	-0.180676	23.052663	23.052663	25.937349	17.079788	17.079883	20.894755	-29.88407
142	-0.886318	-0.886318	47.827708	47.827708	56.441966	22.612481	22.612472	30.608762	-41.565106
33	-15.149189	-15.149189	84.418413	84.418413	80.682864	70.501639	70.501644	90.348993	73.972603
13	-6.375846	-6.375846	98.903165	98.903165	98.396951	27.019434	27.019384	36.910905	-64.285714
113	0.206229	0.206229	122.06041	122.06041	103.064642	115.403486	115.403349	65.192325	-5.153475
42	-3.8366	-3.8366	806.735267	806.735267	427.069334	253.504369	253.504516	105.721388	-79.135539
43	-0.163133	-0.163133	2185.32361	2185.32361	2741.06324	1227.385378	1227.31723	1315.34781	-14.916615

Some of the KINEROS elements experienced up to a 2185% increase in runoff caused by changes in land cover between 2001 and 2006, though the two elements with the largest change are small and over 50% of their area changed from a non-developed land cover class to a developed land cover class. The other elements experienced a more moderate change.